**Collection and analysis of marine species functional traits**

26/09 – 27/09/2017

**Background of Workshop:** Ecosystem modelling is complex and resource intensive. Creating species functional groups improves efficiency as species will not be modelled individually. Functional groupings are often based on expert knowledge and species diet. However, species interactions in an ecosystem are also influenced by their life history and morphology. Life history variables add information on how a species uses its environment and how it changes over time. Morphology characteristics may be used to infer dietary preferences and how a species interacts with its environment. There are two major hurdles for defining functional groups with this type of data. First, which functional traits to define for different species groups and second which method to use to identify the groups. One potential solution is to use cluster analysis to identify species functional groups and the variables that contribute significantly to that grouping choice.

**Aims and outputs of Workshop:** The workshop aims to bring together marine ecologists to create a functional traits database of temperate coastal marine species in Australia/New Zealand and cluster analysis specialists to identify the best way to analyse the data currently available. Such a database does not currently exist. Results will include a list of traits important for defining different functional groups, and identification of the best cluster analysis techniques for analysing this type of data.

*Day 1: Building a trait matrix*

What are the functional traits of different groups of marine species (benthic invertebrates, teleost fish, elasmobranchs and cephalopods) needed to define functional groups and how do we measure them?

*Day 2: Statistical analysis*

What are the most appropriate statistical methods for defining functional groups, and how do we decide that we have a good fit?

**Attendees:**

Beth Fulton (or representative) – CSIRO; Shirley Pledger - Victoria University of Wellington; Nokuthaba Sibanda - Victoria University of Wellington; Matt Dunn – NIWA; Judi Hewitt– NIWA; Michelle Masi – NIWA; Roy Costilla – University of Queensland;
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter</th>
<th>Questions</th>
<th>Expected outcomes</th>
<th>References</th>
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<td>Day 1 Tuesday 26-09-2017</td>
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<tr>
<td>9:00 – 9:30</td>
<td>Introductions and outline for the workshop</td>
<td>Monique Ladds</td>
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<td>Agreement on outcomes to be achieved for the workshop</td>
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<td>9:30 – 10:00</td>
<td>Session 1: Fundamentals of ecosystem models</td>
<td>Michelle Masi</td>
<td>Why do we need functional groups? How do they fit into ecosystems models?</td>
<td>Set up the underlying basis for the problem</td>
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<td>10:00 – 10:45</td>
<td>Half an hour plus discussion.</td>
<td>Beth Fulton</td>
<td>How sensitive are the models to functional groups? How are we currently dealing with functional groups?</td>
<td>Overview of the Atlantis model and possible extensions.</td>
<td>Fulton et al., 2001, 2003</td>
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<td>10:45 – 11:15</td>
<td>Break</td>
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<td>11:15 – 12:00</td>
<td>Half an hour plus discussion.</td>
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<td>11:00 – 13:00</td>
<td>45 minutes plus questions – for whole dept.</td>
<td>Mark Westoby</td>
<td>What can we learn about using functional traits to define functional groups for marine species from other well studied groups?</td>
<td>Develop an understanding of how functional traits have been used to develop functional groups.</td>
<td>Madin et al., 2016 TREE</td>
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<td>12:00 – 13:00</td>
<td>Session 4b: Functional traits of benthic invertebrates</td>
<td>Judi Hewitt</td>
<td>Which functional traits matter and why? How are they different? How do we know? What matters why and when?</td>
<td>Build an idea of what traits should be included in order to create a functional group.</td>
<td>Hewitt et al., 2008</td>
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<td>13:00 – 14:00</td>
<td>Lunch</td>
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<td>14:00 – 14:45</td>
<td>Session 5: Meristics and morphology</td>
<td>Anthony Gill</td>
<td>What should and could we measure for each of the different classes? How do we measure them?</td>
<td>Outline the possible traits to measure and discover why those traits are important.</td>
<td>Sibbing et al., 2000</td>
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<td>14:45 – 15:15</td>
<td>Break</td>
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<td>15:15 – 16:15</td>
<td>Session 5: Selecting traits to define functional groups</td>
<td>Monique Ladds/ Matt Dunn</td>
<td>What are the important functional traits to measure to create functional groups?</td>
<td>Facilitated discussion around the different traits that should be recorded for different classes of marine species.</td>
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<td>16:15 – 17:00</td>
<td>Half an hour plus discussion. Session 6: Challenges of validation of the functional groups.</td>
<td>Matt Dunn</td>
<td>What do we need to make functional groups for ecosystems models? How do we validate and can we validate?</td>
<td>Bring together the ecology and the statistics of what is needed to make functional groups that are useful for ecosystem modelling.</td>
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<td>19:00</td>
<td>Dinner</td>
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<td>Day 2</td>
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<td>9:00 – 9:45</td>
<td>Session 7: Statistical analysis – data preparation</td>
<td>Monique Ladds</td>
<td>How do we deal with missing data? Should the data be transformed?</td>
<td>Find an appropriate method of dealing with missing data. Show the different impacts of transforming data.</td>
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<td>9:45 – 10:30</td>
<td>Session 8: Statistical analysis – selecting the most important traits and number of functional groups</td>
<td>Roy Costilla</td>
<td>Of the traits selected to be collected for analysis, which contribute the most to explaining group membership?</td>
<td>Dimensionality reduction methods: Bi-clustering as an alternative to two-step process of dimension reduction + clustering</td>
<td>Bremner et al., 2006</td>
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<td>Break</td>
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<td>11:00 – 11:45</td>
<td>Session 9: Statistical analysis – options for finding groups</td>
<td>Shirley Pledger</td>
<td>How do we find the functional groups of marine species without any prior knowledge?</td>
<td>Outline some possible statistical analyses that can be used for creating functional groups.</td>
<td>Fernandez and Pledger 2015</td>
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<td>11:45 – 12:30</td>
<td>Session 10: Simulation and cross validation</td>
<td>Nokuthaba Sibanda</td>
<td>How do we validate our approach?</td>
<td>Show the methods available for simulating data and provide options for cross-validation</td>
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<td>12:30 – 13:00</td>
<td>Session 11: Bringing it all together – data collection, analysis and publications</td>
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<td>What do we need to make functional groups for ecosystems models?</td>
<td>Bring together the ecology and the statistics of what is needed to make functional groups that are useful for ecosystem modelling. Make a timeline of papers to be written and delegate tasks.</td>
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<td>13:00 – 14:00</td>
<td>Lunch and talk from Asta Audzijonyte</td>
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**Lunch time talk abstracts:**

**Using benthic macro-species biological traits: which traits and what for?**

**Judi Hewitt, Simon Thrush, Anna Villnäs**

Use of the biological traits of marine species has expanded rapidly since the Bremner et al 2003 paper introduced the topic to a marine audience. However, specific biological traits have formed the basis of many ecological theories (e.g., habitat-related effects on biodiversity, succession theory) and impact assessment (responses to enrichment and fishing activities). Today, biological traits are used for a range of purposes, e.g.: assessing sensitivity of locations to various human activities; understanding resilience via functional diversity and redundancy; assessing ecosystem functionality and services; and predicting/modelling disturbance/recovery processes. Most studies demonstrate that results are dependent on which biological traits are included and whether they are grouped to functions. In reality, the traits or grouping used depends on the question(s) behind the study. Here I summarise some NZ and Finnish work that looks at what traits might be useful for particular questions, whether particular traits co-occur and how we assign species to traits.

**Reproduction cost as a fundamental species trait and how it can explain fish life-histories**

**Asta Audžijonyte**

In many species reproductive behaviour, such as migration, mating, nest guarding or competition for mates entails remarkable energetic costs. These costs will set the minimum individual’s condition or energy required for reproduction and will affect the optimal maturation size and age. Further, at least in aquatic ectotherms and particular in fish, the relative reproduction cost often declines with individual’s size. It seems that a number of fish life-history strategies, such as delayed maturation, skipped spawning and indeterminate growth can be explained when the cost of reproduction is taken into account. Declining relative reproduction cost can also help explain why “big old fat fecund female fish (BOFFFs)” seem to provide disproportionally high contribution to population growth. Yet, most ecological models do not include energetic reproductive cost in individual’s energy budget and assume that spawn increases linearly with female’s body mass. I will present an ectotherm growth model with explicit energetic and survival cost of reproduction. The model can reproduce a range of emergent growth trajectories, maturation ages and reproductive outputs. The model is parameterised for the Baltic Sea cod (*Gadus morhua*) and used to explore optimal maturation age and size at different fishing mortality regimes. We find that under high fishing mortality the optimal maturation size of the Baltic Sea cod is ten times larger than what was suggested in earlier models that did not include reproduction cost. Moreover, since reproduction cost sets limits on how early maturation can occur, increasing fitness under high fishing mortality is instead achieved by diverting most energy to reproduction, even if that results in very low post-reproductive condition and high mortality.